

1 Improved Shoe

2

3 The present invention relates to a tubing shoe for use in  
4 well bores as are typically utilised in oil and gas  
5 production.

6

7 After boring or drilling a region of an oil or gas well a  
8 "string" of tools and/or tubing is typically run into the  
9 well bore. As the string is run it can meet obstructions  
10 as it travels through the well bore. These obstructions  
11 may be ledges that form from well material during boring,  
12 formation wash-outs, or debris formed by unstable  
13 sections of the well bore wall collapsing. Bridges of  
14 shale and clay stone can also be formed. Such  
15 obstructions can result in the string jamming in the well  
16 bore.

17

1 To prevent or minimise the effect of these obstructions,  
2 a guide shoe is conventionally mounted on the lower end  
3 of the string.

4  
5 For example, after boring a region of an oil or gas well,  
6 it is normal to run tubing or casing into the well bore  
7 to act as a lining. The casing is typically run into the  
8 well bore from the surface and the length of casing is  
9 often referred to as a "casing string". The lining of  
10 the well bore can then be strengthened by introducing  
11 cement between the external surface of the casing and the  
12 internal surface of the well bore. As the casing is run  
13 there is a risk of the casing string jamming as it meets  
14 obstructions in the well bore. To prevent or minimise the  
15 effect of the obstructions, a guide shoe, referred to as  
16 a reamer shoe, is conventionally mounted on the lower end  
17 of the casing string.

18  
19 A typical reamer shoe has two features; a nose portion  
20 designed to guide the casing through the centre of the  
21 wellbore, so reducing the risk of the casing string  
22 jamming against the bore wall, and a reaming portion  
23 around the body of the shoe which removes any  
24 irregularities or obstructions from the wall of the bore,  
25 and thereby ease the passage of the casing string. When  
26 the casing is successfully positioned and set in place,  
27 the nose portion may be drilled out to leave a  
28 throughbore for the passage of tools to drill and case  
29 the next section of the well bore. The dual purpose of  
30 the shoe requires that the material of the nose cone is  
31 soft, and therefore easily able to be drilled out and the  
32 material of the reaming portion must be hard, so that it  
33 can successfully remove obstructions on the wall of the

1 bore. Ideally, the shoes are constructed of two  
2 materials; a body comprising the reamer is made of a hard  
3 material, such as steel, while the nose portion is made  
4 of a soft material, such as aluminium. The shoes are  
5 typically a two-part construction, with the nose portion  
6 screwed into an annular sleeve that includes the reamers.

7  
8 Reamer shoes generally may be used in two modes; the  
9 casing string and reamer shoe may be rotated and advanced  
10 in the manner of a drilling operation, alternatively the  
11 casing string and the reamer shoe may be reciprocated to  
12 provide a rasping action against partial obstruction in  
13 the well bore. In general, the reciprocating mode would  
14 be preferable when the threaded casing connections are  
15 considered too weak to support the rotational torsion  
16 required to turn and ream away at obstructions. In order  
17 that a single design of reamer shoe may be conveniently  
18 used in either manner, certain combinations of features  
19 have been brought together in a single unit. It will be  
20 seen that although these combinations improve performance  
21 in certain aspects, they compromise performance in other  
22 aspects.

23  
24 Certain reamer shoes incorporate helical reaming members  
25 giving full circumferential coverage to assist in rasping  
26 the entire bore hole wall when operated in the  
27 reciprocating mode. An example of such a shoe is that  
28 disclosed in US 6,401,820. This feature may be seen to  
29 be detrimental in certain circumstances by reference to  
30 the manner in which casing joints are mated together.  
31 Casing joints are invariably threaded and screwed  
32 together prior to running into the well bore. It will be  
33 appreciated that upon engaging an obstruction and

1 attempting to overcome it by reciprocation, a helical  
2 reaming member will inevitably impart a rotational action  
3 to the casing string as it slides over and past the  
4 obstruction. Depending on whether the helical reaming  
5 member is clockwise or anti-clockwise, the reamer shoe  
6 may impart a tightening or untightening torsion to the  
7 threaded connections higher up in the casing string. As  
8 has been stated, threaded casing connections may be  
9 relatively weak and could be damaged if over-tightened.  
10 Conversely, if rotated in the opposite direction, the  
11 connections may be loosened. Either outcome is  
12 undesirable and could result in serious consequences for  
13 the well bore construction operation.

14  
15 A further undesirable consequence of anti-clockwise  
16 helical reaming members may be apparent when this style  
17 of reamer shoe is used in the normal clockwise rotational  
18 mode. The rotating helical members impart a restraining  
19 influence on the flow of well bore fluid and in  
20 particular on the solid components entrained in the  
21 fluid, generated by the reaming process. The result is a  
22 gradual increase in the concentration of solid material  
23 ahead of the reaming elements that can pack-off the  
24 reaming area, rendering it ineffective. In order to clean  
25 the reaming members it may be necessary to pick-up the  
26 reamer shoe and circulate fluid at a high rate, if this  
27 is unsuccessful, then the reamer shoe along with the  
28 entire casing string would have to be removed from the  
29 well bore. It will be appreciated that this is a highly  
30 undesirable operation.

31  
32 Another design of reamer shoe uses multiple diamond-  
33 shaped reaming members to overcome the negative aspects

1 of the helical reaming design. US 2003/0075364 provides  
2 an example of diamond-shaped reaming members. A feature  
3 of this design is that each reaming element has a leading  
4 edge. It will be apparent to those skilled in the art,  
5 that the leading edge of each element is a potential site  
6 for hanging-up whilst tripping into the well bore.

7 Hanging-up is a phenomenon where tools that ideally can  
8 be run into a well bore with a smooth and uninterrupted  
9 action, may intermittently come to a halt when sudden  
10 changes in a section of the tool string and of the well  
11 bore come into contact. Hanging-up is at best an  
12 inconvenience, at worst, it can result in the entire  
13 casing string being pulled from the well to investigate  
14 the cause of the problem.

15

16 Yet another design of reamer shoe uses a reaming  
17 structure that converges towards the forward end of the  
18 nose of the reamer shoe. This design is illustrated in US  
19 6,062,326. One undesirable consequence of this design is  
20 that relatively large pieces of well bore formation may  
21 pass by the reaming members without being ground-up. If  
22 these pieces exceed a certain size, they may not be  
23 carried back to the surface by the flow of well bore  
24 fluid. In this event, they can fall back to the upper end  
25 of the reamer shoe and collect there. There are certain  
26 common circumstances where this may be an undesirable  
27 outcome. Firstly, after reaming to the bottom of the well  
28 bore, it is normal practice to cement at least the lower  
29 section of the casing string, including the reamer shoe  
30 itself, in place. In order that a good strong cement bond  
31 is made it is important that the well bore fluid along  
32 with contaminants such as cuttings are circulated out  
33 before the cement is put in place. With large pieces of

1 well bore formation collecting above the reamer shoe,  
2 this may not be possible. The outcome could be a  
3 contaminated and therefore weak cement bond. Secondly, if  
4 it were necessary to reciprocate the casing string when  
5 the upper part of the reamer shoe had a collection of  
6 cuttings above it, it could be seen that on the upstroke  
7 the cuttings would become jammed between the reamer shoe  
8 and the hole-wall. In the worst circumstances, it may not  
9 be possible to free the reamer shoe and the casing would  
10 have to be set in the position that it became jammed.

11

12 It is an object of the present invention to provide a  
13 shoe that overcomes these and other limitations of  
14 existing shoes.

15

16 According to a first aspect of the present invention  
17 there is provided a shoe for use on the end of a work  
18 string within a well bore, the shoe comprising a  
19 generally cylindrical body having a first end adapted for  
20 connection to the work string and a second end including  
21 a nose portion; the nose portion including a rounded head  
22 distal to the body for advancement through the well bore;  
23 the body having thereupon a reaming portion located  
24 behind the nose portion wherein the reaming portion  
25 comprises a plurality of raised members, each pair of  
26 raised members being mounted oppositely, in parallel and  
27 longitudinally along the body, wherein each adjacent pair  
28 of members provides a funnel for collecting approaching  
29 debris and a channel for grinding the debris.

30

31 In this way the leading portions of the reaming members  
32 have diverging edges, stopping large pieces of formation  
33 being circulated through the tool. All pieces above a

1 certain sizes will necessarily be ground up before being  
2 allowed to exit the reaming portion. In addition by  
3 making the members non-helical and extend the length of  
4 the reaming portion, the shoe operates well in both  
5 rotation and reciprocation.

6  
7 Preferably the reaming members are elongate and  
8 continuous. Preferably also, the reaming members are  
9 teardrop shaped. In this way, one end of each reaming  
10 member is wider than the opposing end and both ends are  
11 rounded.

12  
13 Preferably the funnel comprises diverging edges of  
14 adjacent reaming members. Preferably the channel provided  
15 between each pair of members converges from the nose  
16 portion along the reaming portion. This improves the  
17 grinding and breaking down ability of the shoe without  
18 compromising the flow by area provided by the channels.  
19 The funnel will guide flow and debris into the channel.

20  
21 Preferably the nose portion is eccentric to aid the  
22 passage of the shoe through the well bore. In this way  
23 the nose has an end offset from the central axis of the  
24 shoe. Advantageously the nose portion includes one or  
25 more ports. The ports may direct fluid within the shoe,  
26 forward of the shoe or rearwards over the reaming  
27 members. In one embodiment of the shoe, the nose portion  
28 includes a plurality of blades extending from the end of  
29 the nose towards the reaming portion. The blades may  
30 include a cutting surface to assist in breaking through  
31 shale and clay stone bridges.

32

1 The shoe may further comprises a gauge portion.  
2 Preferably the gauge portion is located furthest from the  
3 nose portion. Preferably the gauge portion is a  
4 stabiliser. More preferably the gauge portion comprises a  
5 plurality of elongate blades. Advantageously the blades  
6 are arranged helically along the body. In this way a non-  
7 aggressive stabiliser is provided on the shoe.

8  
9 According to a second aspect of the present invention  
10 there is provided a shoe for use on the end of a work  
11 string within a well bore, the shoe comprising a  
12 generally cylindrical body having a first end adapted for  
13 connection to the work string and a second end including  
14 a nose portion; the nose portion including a rounded head  
15 distal to the body for advancement through the well bore  
16 and a plurality of blades extending from the head towards  
17 the body; the body having thereupon a reaming portion  
18 located behind the nose portion wherein the reaming  
19 portion comprises a plurality of discrete raised members  
20 to ream the bore.

21  
22 The reaming members may be arranged in any configuration  
23 on the reaming portion. The shoe therefore  
24 advantageously 'cuts through' and debris or blockage in  
25 the well bore prior to reaming the bore. Preferably the  
26 reaming members are as described with reference to the  
27 first aspect. In this way the reaming members provide  
28 complete circumferential coverage of the body, are  
29 continuous and extend fully along the reaming portion.

30  
31 Preferably the shoe is constructed from a combination of  
32 relatively hard and relatively soft materials. In this  
33 way the blades and reaming portions can effective at

1 cutting through debris and reaming the bore while the  
2 shoe can be drilled through when necessary.

3

4 The shoe may further comprises a gauge portion.  
5 Preferably the gauge portion is located furthest from the  
6 nose portion. Preferably the gauge portion is a  
7 stabiliser. More preferably the gauge portion comprises a  
8 plurality of elongate blades. Advantageously the blades  
9 are arranged helically along the body. In this way a non-  
10 aggressive stabiliser is provided on the shoe.

11

12 Embodiments of the present invention will now be  
13 described, by way of example only, with reference to the  
14 accompanying drawings of which:

15

16 Figure 1 is a schematic side view of a shoe according to  
17 a first embodiment of the present invention;

18

19 Figure 2 is a cross-sectional view through the shoe of  
20 Figure 1 at section B-B;

21

22 Figure 3 is an alternative side view of the shoe of  
23 Figure 1;

24

25 Figure 4 is a front view of the shoe of Figure 3;

26

27 Figure 5 is a cross-sectional view through the shoe of  
28 Figure 3 at section A-A; and

29

30 Figure 6 is a schematic illustration of a shoe according  
31 to a second embodiment of the present invention.

32.

1 Reference is initially made to Figure 1 of the drawings  
2 which illustrates a shoe, generally indicated by  
3 reference numeral 10, according to a first embodiment of  
4 the present invention. Shoe 10 comprises a generally  
5 cylindrical body 12 having a nose portion 14 at a first  
6 end 16 and a connector 18 at a second end 20. Connector  
7 18 is adapted to mount the shoe 10 on a work string (not  
8 shown). Connector 18 is typically a threaded connector as  
9 is known in the art.

10

11 Behind the nose portion 14 is located a reaming portion  
12 22. This portion 22 is a longitudinally arranged section  
13 on the outer surface 24 of the body 12. Mounted on the  
14 surface 24 are six reaming members 26a-f. The reaming  
15 members 26 are constructed from a hard resistant material  
16 such as polycrystalline diamond compact or tungsten  
17 carbide, or a combination of both materials.

18

19 Each reaming member 26 has a teardrop shape. This  
20 provides a first end 28 having an apex 30. Diverging from  
21 the apex 30 are sloping edges 32. The edges 32 then turn  
22 at a corner 34 to provide longitudinally extending  
23 convergent edges 36 which terminate at a rounded corner  
24 38. The rounded corner 38 is at a second end 40 of the  
25 reaming portion 26, opposite the first end 28 and at the  
26 end of the reaming portion 22.

27

28 As further illustrated with the aid of Figure 2, the  
29 reaming members 26 are oppositely arranged, in pairs,  
30 circumferentially around the outer surface 24. In lying  
31 side by side, a funnel 42 is created toward the nose 14  
32 of the reaming portion 22. Debris, fluid and the like is  
33 effectively guided by the funnel arrangement 42 bounded

1 by the edges 28,36. This matter is then ground up as it  
2 passes through a channel 44 between adjacent edges 36 of  
3 the reaming members 26. The edges 36 converge towards the  
4 second end 40. Though six reaming members 26 are  
5 illustrated, it will be appreciated that any even number  
6 of members 26 could be used.

7

8 This arrangement of reaming members 26 work effectively  
9 in both the rotating and reciprocation modes the shoe may  
10 be used in. Additionally sufficient flow area is provided  
11 around the members 26 to ensure that cuttings are  
12 effectively swept down the side of the shoe while being  
13 ground in the channels 44. A typical flow area is 65% of  
14 the circumferential area at the members 26, as  
15 illustrated in Figure 2.

16

17 Reference is now made to Figures 3 and 4 which, with  
18 Figure 1, illustrate the nose portion 14 of the shoe 10.  
19 Like parts to those in Figure 1 have been given the same  
20 reference numerals to aid clarity. Nose portion 14 is an  
21 eccentric portion connected to the front 16 of the shoe  
22 10. The nose 14 has a snubbed end 46, rounded to provide  
23 guide for the shoe 10 through a well bore. Nose 14 may be  
24 rotatably mounted to the body 12.

25

26 Body 12 is hollow having a bore 48 there through. Fluid  
27 such as drilling fluid may be pumped towards the shoe  
28 through the bore 48. Upon the nose 14 is a jetting port  
29 50 which allows the fluid to exit the shoe 10 and  
30 lubricate the advancing nose through the well bore.  
31 Additionally rearwardly directed ports 52a,b are  
32 positioned on the nose 14. These ports 52a,b direct fluid  
33 back to the reaming members 26 to aid the clearing of

1 cuttings and debris in the channels 44. The ports 50, 52  
2 are all recessed and do not lie on the central axis of  
3 the nose portion 14.

4

5 The nose 14 is typically formed of a relatively soft  
6 material such as an aluminium alloy. The material is  
7 chosen so that a drill may be passed through the bore 48  
8 and the nose 14 drilled through when the shoe has  
9 completed its task.

10

11 Mounted behind the reaming section is a stabiliser  
12 portion, generally indicated by reference numeral 54. The  
13 stabiliser may be used to provide a particular  
14 directional response from the tool or to act as a pivot  
15 point to assist the shoe in negotiating obstacles. As  
16 illustrated in Figures 3 and 5, stabiliser 54 comprises  
17 six spiral flutes 56 arranged on the outer surface 24 of  
18 the body 12. Each flute 56 is an elongate band arranged  
19 substantially helically on the surface 24. While six  
20 flutes 56 are illustrated any number of flutes 56 may be  
21 used. It may however, be advantageous to have the same  
22 number of flutes 56 as reaming members 26 and align the  
23 leading edge 58 of each flute with the end 30, 40 of each  
24 reaming portion 26. In this way a series of generally  
25 uninterrupted flow paths are provided along the length of  
26 The shoe 10.

27

28 The outer faces of the flutes 56 may also be provided  
29 with a hard facing of tungsten carbide or the like and  
30 their trailing ends 60 may also be provided with abrasive  
31 elements, such as aggressive tungsten carbide, to assist  
32 back-reaming. The forward ends 58 of the spiral flutes 56  
33 may similarly be provided with abrasive elements, to

1 protect the flutes from damage during forward motion of  
2 the shoe.

3

4 In use, the shoe 10 may be located on a lower end of a  
5 length of tubing, typically liner, which is then run into  
6 a well bore. The upper section of the bore will have been  
7 previously lined with steel casing, such that initial  
8 passage of the shoe and liner into the bore should be  
9 relatively straightforward. However, as the shoe 10 and  
10 the leading end of the liner move into the lower unlined  
11 part of the bore, the shoe 10 is likely to encounter  
12 ledges, deposits of cuttings, and other obstructions.  
13 These may be dislodged or pushed aside by the shoe 10, or  
14 the fluid passing from the shoe 10. However, on occasion  
15 it may be necessary to rasp or ream past an obstruction  
16 using the reaming members 26. This may be achieved by  
17 rotating the liner and shoe 10 in either direction so  
18 that the reaming members 26 rasp or ream the obstruction  
19 to an extent that the shoe 10 and the liner may pass. The  
20 shoe 10 may also be reciprocated to aid passage passed an  
21 obstruction. The divergent edges 32, 36 prevent hanging-  
22 up and stop larger pieces of debris being circulated  
23 through the shoe 10. All pieces above a certain size  
24 will be forced toward the channel 44, by the funnel 42,  
25 and ground-up before exiting the reaming portion at an  
26 upper end of the shoe. Once the liner is in place, a  
27 drill may be inserted in the bore 48 and the nose portion  
28 14 drilled through. This will provide a clear bore  
29 through the liner and the shoe 10.

30

31 An alternative embodiment of the shoe 10, is illustrated  
32 in Figure 6 as shoe 110. Like parts to those of Figures 1  
33 to 5 have been given the same reference numeral with the

1 addition of 100. Shoe 110 has a nose portion 114, a  
2 reaming portion 122 and a stabiliser portion 154. The  
3 reaming portion 122 and the stabiliser 154 are identical  
4 to those described with reference to Figures 1 to 5. In  
5 this embodiment the nose portion 114 is provided with  
6 three blades 70 on the outer surface 72 thereof. The  
7 blades meet at an apex 74 of the nose at the forward end  
8 of the shoe 110 and splay back towards the reaming  
9 portion 122 so that their trailing ends 76, are  
10 equidistantly spaced around the circumference of the body  
11 112. Flow ports 78 are also arranged between neighbouring  
12 blades 70. Any number of blades may be used, however, it  
13 may be advantageous to have a trailing edge 76 aligned  
14 with an apex 30 of the reaming members 26 so that  
15 cuttings from the blades 70 are directed into the funnels  
16 42.

17  
18 The blades 70 are made from a relatively soft material  
19 such as aluminium or a non-metal. The apex 74 pilots the  
20 shoe through the drilled well bore to aid in breaking  
21 through shale/clay stone bridges and other obstructions.  
22 The choice of material makes the nose 114 easy to drill  
23 through when the liner is in position and is cheaper than  
24 the current drill bits which are located on some shoes to  
25 drill a well bore and run a liner in a single trip.

26  
27 The principal advantage of the present invention is that  
28 it provides a shoe for use on the end of a work string  
29 within a well bore which can be rotated and reciprocated  
30 without the problems experienced by the shoes of the  
31 prior art.

32

1 It will be appreciated that modifications and  
2 improvements may be made to the embodiment hereinbefore  
3 described without departing from the scope of the  
4 invention. For example, the embodiments described relate  
5 to a reamer shoe guiding a casing string through a well  
6 bore, those skilled in the art will appreciate that any  
7 guide shoe and string combination is within the scope of  
8 the invention. For example a guide shoe and a drill  
9 string may be used.